NATIONAL FLOOD FORECASTING SYSTEM

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I. INTRODUCTION

The Bureau of Hydrology (BOH) is a non-profit agency affiliated to Ministry of Water Resources (MWR) with administrative function. BOH takes following responsibility: managing hydrologic sector all over China; organizing and providing guidance to monitor and analyze water quantity and quality of surface water and ground water as well as assess water resources; collecting, processing and forecasting precipitation information and water regime for state key flood control areas and important large-sized reservoirs and providing decision-making support to State Flood Control and Drought Relief Headquarters. The division of hydrologic information and forecasting (DHIF) supports this mission not only by providing flood forecasting and warning for the protection of life and property and but also basic hydrologic information for improvement of economy and environment. The hydrologic experts of DHIF design, develop, test and implement a hydrologic forecasting system--the National Flood Forecasting System (NFFS) by associating with experts of related universities and institutes. In future, NFFS will be applicable to hydrologic forecasting sector of BOH in 31 provinces and 7 large river authorities as well as 244 local hydrologic centers in China.

II. BACKGROUND

After late 1980s, with the popularity and evolution of computer technology, varied flood forecasting software were developed respectively by hydrologic information and forecasting sector in different levels. However, owing to lack of uniform management, these locally developed software programs introduced three major problems into flood forecasting. First, these independent software were developed according to specifically requirement and objective. With the hydroclimatic variation in China from humid to arid conditions, there is no flood forecasting system which include all the features needed to model the flow in rivers in the varied hydrometeorologic regimes. Second, these software had a rigid program structure which made it difficult to add new modules as additional features were developed. The hydrologic modeling structure required that all basins use the same models in a fixed sequence. Third, the software was dependent on the individual who did the initial development. When that person changed jobs or retired, much of the knowledge of how to run the programs, or how to maintain or enhance the programs was lost.

III. NATIONAL FLOOD FORECASTING SYSTEM

With the implementation of National Flood Control Command System project, the uniform standard real-time database will be built in hydrologic information centers of national, provincial and local BOH. It supports the technique basis for NFFS. In 1998, the BOF of MWR began a project to design the NFFS. A major objective of the project was to develop a system structure which looked toward the future of flood forecasting. The basic design requirement for NFFS is (1) to found standard advanced software and hardware configuration based on the uniform standard real-time database and client/server environment, (2) to adopt modular structure to easily add new models and procedures to keep up with technological changes, (3) to let the user control the selection of models and the sequence of use, (4) to have a model calibration system which combined manually and automatically calibration method, (5) to allow the user to flexibly control real-time processing and use graphical and tabular interface for interactive forecasting, (6) to efficiently process large amounts of data to produce forecasts at hundreds of locations, (7) to have integrated powerful flood forecasting management function.

At present, the major parts of NFFS is shown as following:

(1) Software and hardware configuration of NFFS

The software and hardware configuration of NFFS include computer hardware platform, computer operating system above Windows 95 and standard real-time database as well as client/server environment. The NFFS software was installed in client computer. There are three database i.e. IDBS, FDBS and MAPS in server. IDBS is the real-time database. FDBS is forecasting database to store the model code, parameter, state, flood forecasting scheme, forecasting result, historical hydrometeorologic data and user information. MAPS is map database of electronic map files in MAPINFO file form. MAPS uses MAPX desktop software which have a powerful capacity to display and manage river, topography, basin boundary, gauging station distribution, Thiessen polygon boundary, real-time and forecasting information query for forecasting location.

(2) Flood forecasting models and methods

NFFS adopts complete modular structure so that modules can be independent of system and components could be developed by a number of individuals. The user can easily add new moles and methods based on standard I/O files form and flexibly select a set of models and methods to build a forecasting scheme for any subbasin. At present, hydrologic models in NFFS can be selected from the following list:

Soil	Xinanjiang Soil Moisture Accounting	SMS_3
	Rain-Runoff correlation Method	P_RZHJR
Channel	Lag and K Routing	LAG_3
	Muskingum Routing	MSK
	Unit Hydrograph	UH_B

	Diffusion Wave	KSB
Utility	Empirical Model	P######

These hydrologic models was compiled to dynamic link libraries with 32 bit as outer function.

In NFFS, there are 9 variety of standard I/O files including model parameter file, model initial state files, water level and discharge input in same interval time file, observed water level and discharge input file, point rainfall input file, areal rainfall input file, net rainfall input/output file, model terminal state file, water level and discharge output in same interval time file. These 9 files can be stored in one file according to fixed sequence of use as module interface parameter. If the I/O of conceptual model and empirical model can be programmed based on above description, it will be a general standard forecasting model.

(3) Forecasting scheme

The flood forecasting schemes embody that a set of models and methods selected considering the features of related rivers. The user can found and manage easily forecasting schemes for consecutive forecasting from upstream to downstream by friendly human-machine interface in NFFS. The processing include inputting code, lead time of forecasting scheme, basin boundary, code of gauging stations selected, weights of precipitation stations, code, parameter, state, interval time, prepare time of models selected, rating curve, warning threshold and illumination.

(4) Model calibration

Calibration of model parameters can be completed well by error and trial and automatic calibration method based on human-machine interface in NFFS. The Simplex and Rosenbroke optimize methods were adopted in calibration module of NFFS. The independent calibration module is only related to parameters optimized and objective function selected so that the module can be easily updated.

Two objective functions i.e. coefficient of determination and water balance can be selected. Threshold of objective function can be selected according requirement of user.

(5) Real-time operational forecasting

In NFFS, there are interactive forecasting and automatic timing forecasting. The automatic timing forecasting means NFFS can automatically accomplish forecasting by forecasting scheme and sequence selected every hour. Interactive forecasting can provide the information to forecaster for the correction of data and simulated results. The interactive forecasting module can deal with rainfall input, rainfall in lead time, runoff input, model parameter, model state, rating curve, results and adjustment optimization by graphical interface.

Forecasting error statistic module can analyze all forecasting results for any forecasting location to compare the accuracy of forecasting schemes and assess capacity of forecaster.

(6) Utility modules

In NFFS, a number of data processing modules were developed, including model parameter file production module, model state file production module, Thiessen polygon area calculation module, point rainfall in same interval time calculation module, rainfall distribution module, water lever and discharge conversion module, forecasting error adjustment module and forecasting scheme I/O module etc.

(7)System management

NFFS has powerful system management function including user management, forecasting model management, forecasting scheme management, hydrologic station management.

User management includes administrator, general user and SA level. Administrator can add, delete, modify forecasting model, distribute forecasting scheme, manage automatic timing forecasting, user information; General user can construct, delete, modify, calibrate and operate its own forecasting scheme; SA can only manage electronic maps.

Hydrologic station management includes system station management and scheme station management. System station management can add, delete, modify the feature of hydrologic station in electronic map by SA; Scheme station management can add, delete modify the precipitation station used in scheme by general user.

IV. FUTURE ACTIVITIES

As the NFFS moves forward, there are many functions should be developed:

(1) New hydrologic models

In future, general hydrologic models in China or in other countries will be filled in NFFS.

(2) New hydraulic models

The hydraulic model should be adopted for river network regions.

(3) Runoff prediction module

Runoff prediction is very important for water shortage, water distribution, water resources integrated management.

(4) Reservoir operation module

The terminal objection of forecasting is aim at decision-making support. The reservoir operation module should be developed.

(5) Three-dimension map display

The display and query of three dimension topography data can be accomplished by three-dimension map management software.

(6) Browser/server environment

Browser/server environment will be developed so that administrator easily manage and update the NFFS.